Increasing Automation: Good News, Bad News

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NTSB 101

– Independent agency, investigate transportation accidents, all modes

– Determine probable cause(s) – but not blame or liability – and make recommendations to prevent recurrences

– ***SINGLE FOCUS IS SAFETY***

– Primary product: Safety recommendations
  - Not a regulator, cannot require anything, but recommendation acceptance rate > 80%

But First -- Two Other Issues

- Pilot professionalism
  - Loss of military pipeline
  - Civilian filters not sufficiently robust
  - Recent troubling events
- Overzealous criminalization of accidents
  - Undercuts proactive information programs
  - Hinders investigations
  - Reduces likelihood of addressing system issues

Increasing Automation: Good News, Bad News

– *Good:* When working as designed, automation has demonstrated that it can and does significantly improve safety, reliability, and productivity

– *Bad:* Problems may occur if the automation
  - Has design flaws,
  - Is not appropriate for the situation,
  - Malfunctions, or
  - Is relied upon too much

What’s the Problem?

– Increasing likelihood of a bad outcome if any of those problems arise because:
  - More complexity increases likelihood that operators (e.g., pilots) will not completely understand the system
  - More reliability increases likelihood that operators have never seen a given unanticipated automation action or malfunction before, even in training
  - Automation often masks the problem of less proficient operators – until something goes wrong

Examples

- Design Flaws
  - Metro, Washington, DC (2009)
  - Strasbourg, France (1992)
  - Cali, Colombia (1995)
- Design Inappropriate
  - Miracle on the Hudson (2009)
- Malfunction
  - Amsterdam, Holland (2009)
  - Rio to Paris (2009)
- Over-Reliance
  - San Francisco (2013)

Statement of the Problem

"In their efforts to compensate for the unreliability of human performance, the designers of automated control systems have unwittingly created opportunities for new error types that can be even more serious than those they were seeking to avoid."

Reason, James,

Managing the Risks of Organizational Accidents (Ashgate Publishing, 1997), p. 46

Design Flaws

Metro, Washington, DC

- The Conditions
  - Electronic collision prevention
  - Parasitic electronic oscillation
  - Stopped (struck) train became electronically invisible

  - “Invisibility alarm” at dispatch center – ignored
  - No invisibility alarm to following (striking) train
  - Following train was accelerating, sensing empty track ahead
  - Sight distance limited because stopped train was on a curve

Lessons Learned

– Need to address parasitic oscillation

– Need invisibility alarm in following trains

– Over-warning can lead to warning system complacency, which is often worse than no warning

Strasbourg, France

- Risk Factors
  - Night, mountainous terrain
  - No ground radar
  - No ground-based glideslope guidance
  - No airborne terrain alerting equipment

- Very Sophisticated Autopilot
- Autopilot Mode Ambiguity

Human Factors Challenge

– “3.2” in the window, *with a decimal,* means:
  - Descend at a *3.2 degree angle (about 700 fpm at 140 knots)*

– “32” in the window, *without a decimal,* means:
  - Descend at *3200 fpm*

Flight data recorder readout program could have helped safety experts identify this problem

Clue: Quick changes in autopilot mode frequently signal a problem

Cali, Colombia

- Risk Factors
  - Night
  - Airport in deep valley
  - No ground radar
  - Airborne terrain alerting limited to “look-down”
  - Last minute change in approach
    - ➢ More rapid descent (throttles idle, spoilers)
    - ➢ Hurried reprogramming
- Navigation Radio Ambiguity
- Spoilers Do Not Retract With Power

Recommended Remedies:

– Operational
  - *Caution re last minute changes during the approach!!*
– Aircraft/Avionics
  - Enhanced ground proximity warning system
  - Spoilers that retract with max power
  - Require confirmation of non-obvious changes
  - Unused or passed waypoints remain in view
– Infrastructure
  - Eliminate single-letter navigational radio identifiers
  - Ground-based radar
  - Improved reporting of, and acting upon, safety issues

Design Inappropriate

Landing on the Hudson

- Bird ingestion, dual engine failure
- Dead-stick landing into river
- Unknown to pilot, phugoid damping software restricted nose-up movement during “landing” flare
- Result: Higher vertical impact speed, damage to fuselage

Queries

- Need for phugoid damping in this situation?

- Different result if pilot had known about phugoid damping?

Malfunctions

Amsterdam, Holland

- The Conditions
  - Malfunctioning left radar altimeter
  - Pilots selected right side autopilot
  - Aircraft vectored above glideslope
  - Autothrottles commanded throttles to idle

  - Unknown to pilots, throttles idle because right autopilot was using left radar altimeter
  - Attempted go-around unsuccessful

Queries

– Should autopilot default to same side altimeter?

– More clarity re source of altitude information?

– Enable pilots to select altitude information source?

Rio to Paris

- The Conditions
  - Cruise, autopilot engaged
  - Night, in clouds, turbulence, coffin corner
  - Ice blocked pitot tubes
  - Autopilot, autothrust inoperative without airspeed information
  - Alpha protections disabled
  - Pilots' responses inappropriate

Queries

– Adequate redundancy?
– More effective error message displays?
– Reduction of startle effect, e.g., interim “virtual” airspeed?
– Improved pilot training?
– Improved CRM training: Importance of pilot knowing other pilot’s actions?
– Train manual flight at cruise altitude?

Over-Reliance

San Francisco

- RW 28L: 11,381 x 200, winds < 10 kts, glideslope out of service
- Pilot “Monitoring:” Instructor pilot, more than 12,000 hours, more than 3200 in type

- First instruction flight for Pilot Monitoring
- Pilot Flying: Almost 9,700 hours, but less than 40 in type (after transitioning from A320)
- Pilot Flying had only done visual approaches in simulator, uneasy about doing this one without glideslope

Automation Confusion

– Intercepted localizer 14 miles out, slightly above 3 degree glideslope
– Inside FAF, still high, Pilot Flying selected FLCH SPD
– Unanticipated by PF, selecting FLCH SPD caused
  – Aircraft to pitch up, to decelerate to speed PF selected in MCP
  – Throttles to increase, to climb to altitude PF selected in MCP
– Hence, PF turned off autopilot and overrode throttles
– Overriding throttles put them in “HOLD” mode, inadvertently eliminating “Autothrottle wakeup”
– Inadequate communication between PF and PM, including some missed approach callouts
– Aircraft became low and slow, go-around attempted too late

Queries

- Automation too complicated?
- Effect of PF's Airbus experience?
- Inadequate instructor training?
- PF's failure to communicate unease to instructor?
- Instructor's failure to sense PF's problems earlier, even if not communicated?
- PF's failure to communicate autopilot selections to instructor?
- Missed callouts?
  - Descent greater than 1000 fpm below 1000' AGL
  - Approach stable at 500' AGL?

Conclusions

– Automation has significantly improved safety, reliability, and productivity

– More effective training re automation will always be essential, but

– We must also address more effectively the human/machine interface challenges of increasingly complex and increasingly reliable automation

Thank You

Questions?